AUSTRALASIA EPD®

ENVIRONMENTAL PRODUCT DECLARATION

AUSTRALIA'S PIPELINE SPECIALISTS

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iPLEX Pipelines

ENVIRONMENTAL PRODUCT DECLARATION

PVC NON-PRESSURE PIPES FOR BUILDING APPLICATIONS

Environmental Product Declaration (EPD) in accordance with ISO 14025 and EN 15804

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Geographical area of application of this EPD: Australia

Year taken as a reference for the data: 2014

EPD of Iplex Pipelines PVC Non-Pressure Pipes Pipe Products – In collaboration with the Australian Plastics Industry Pipe Association (PIPA)

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ENVIRONMENTAL PRODUCT DECLARATION

PVC NON-PRESSURE PIPES FOR BUILDING APPLICATIONS

1.0 ENVIRONMENTAL PRODUCT DECLARATION DETAILS

An Environmental Product Declaration, or EPD, is a standardised and verified way of quantifying the environmental impacts of a product based on a consistent set of rules known as a PCR (Product Category Rules). Environmental product declarations within the same product category from different programmes may not be comparable. EPD of construction products may not be comparable if they do not comply with EN 15804.

This version of the EPD has been updated to clarify the definition of “Indicator Not Accessed” in Table 7.

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CEN STANDARD EN 15804 SERVED AS THE CORE PCR	
PCR:	Construction Products and Services, Version 2, 2015-03-03
PCR PREPARED BY	IVL Swedish Environmental Research Institute Moderator: Martin Erlandsson, **e:** martin.erlandsson@ivl.se
INDEPENDENT EXTERNAL VERIFICATION OF THE DECLARATION AND DATA, ACCORDING TO ISO 14025:2010	☐ EPD process certification (Internal) ☑ EPD verification (External)
ACCREDITED OR APPROVED BY	The Australasian EPD® Programme

2.0 GREEN STAR EPD COMPLIANCE

- ✓ The EPD conforms to ISO 14025 and EN 15804.
- ✓ The EPD has been verified by an independent third party.
- ✓ The EPD has at least a cradle-to-gate scope.
- ✓ The EPD has product specific results.

This EPD may be used to obtain Product Transparency credit points under the GBCA's Green Star rating tools.

The PVC pipe EPD results can also be used to represent PVC pipe products in Whole of Building Life Cycle Assessments under Green Star rating tools. See the product details tables to convert the product results from kilogram of installed pipe to length of pipe for individual pipe products.

3.0 IPLEX PIPELINES AUSTRALIA

Iplex Pipelines (Iplex), Australasia's largest manufacturer and supplier of plastics piping systems, is pleased to publish this Environment Product Declaration, for its Iplex "PREMIUM" and Key Plastics "KEYPLAS" brands of non-pressure stormwater, DWV and electrical conduit products.

As a wholly owned business unit of the ASX listed company, Fletcher Building Limited, with operations in every state and New Zealand, Iplex supplies PVC pipe and conduit to applications including plumbing, irrigation, mining, industrial and chemical processes, electrical, gas, stormwater, sewer, raw, recycled and potable water.

More than 50 years' experience in the manufacture of PVC pipes makes Iplex an Australian pioneer in plastics pipe production and a foundation member of the Plastics Industry Pipes Association of Australia. As part of its ongoing commitment to the development of Australian and International Standards for plastics pipe products, company personnel serve on Standards Australia and ISO technical committees and working groups.

PVC pipe manufacturing plants are located close to major development regions in Brisbane, Sydney, Melbourne and Perth and all products comply with the stringent requirements of Best Environmental Practice BEP PVC.

In addition to WaterMark and StandardsMark product certification to AS/NZS 1254 and AS/NZS 1260 all operations are conducted under a quality management system, certified by SAI Global to ISO 9001, Licence QEC 0037.

In support of its extensive product range, Iplex employs professional engineers to assist pipe users and designers and publishes comprehensive engineering design guides that are freely available for download via its website: www.iplex.com.au .

The Iplex PocketENGINEER™ is a web portal where registered users can access design software to simplify hydraulic, structural and chemical resistance aspects of pipeline design.

For more information on Iplex's extensive range of pipeline products, visit www.iplex.com.au.

IPLEX PVC NON-PRESSURE PIPE PRODUCTS

The Australian Standards for PVC pipe (AS/NZS 1260 and 1254) have the Best Environmental Practice requirements developed by the Green Building Council of Australia (GBCA) embedded in them to facilitate and openly encourage responsible sourcing of raw materials, best practice manufacturing, fully independent third party certification compliance, simpler procurement and easier identification of compliant products. No other Australian or international product standards have taken this step. Product characteristics are shown in Table 1 and the content declaration in Properties relate to rigid PVC-U.

TABLE 1 – PRODUCT CHARACTERISTICS OF PVC-U PIPE AT 20°C

PRODUCT CHARACTERISTICS	
PRODUCT NAMES/APPLICATION	Polyvinylchloride (PVC) pipes covered in this EPD are: PVC-U Drainage, Waste and Ventilation (DWV) pipe PVC-U Electrical conduit PVC-U Stormwater pipe *See Table 12 and Table 13 for individual product codes.*
UN CPC CODE	36320 - Tubes, pipes and hoses, and fittings therefor, of plastics
DENSITY	1530 kg/m³
ULTIMATE TENSILE STRENGTH	52MPa
COMPRESSIVE STRENGTH	66MPa
SHORE D HARDNESS	85ASTM D2240
COEFFICIENT OF LINEAR THERMAL EXPANSION	7×10^{-5} / °C
VICAT SOFTENING TEMPERATURE	Approximately 80°C
ELONGATION AT YIELD	5.5%
POISSON'S RATIO	0.38
RING BENDING MODULUS	3 minute 3200MPa and long term 1400MPa

** Properties relate to rigid PVC-U*

TABLE 2 - CONTENT DECLARATION

MATERIAL	PERCENTAGE CONTENT	CAS NO.
POLYVINYL CHLORIDE RESIN	89%	9002-86-2
CALCIUM CARBONATE	7.0%	471-34-1
ORGANIC STABILISER	2.5% CONFIDENTIAL	(NOTHING HAZARDOUS)
TITANIUM DIOXIDE	1.3%	13463-67-7
CALCIUM STEARATE	<0.1%	1592-23-0
POLYETHYLENE WAX	<0.1%	9002-88-4
OXIDISED POLYETHYLENE WAX	<0.1%	68441-17-8
AZODICARBONAMIDE (BLOWING AGENT)*	<0.1%	123-77-3
TOTAL	100%	

**Only used in foam core construction pipe*

PRODUCT LIFE CYCLE OVERVIEW

The life cycle of a building product is divided into three process modules according to the General Program Instructions (GPI) of the Australasian EPD Programme (AEPDP, 2015) and four information modules according to ISO 21930 and EN 15804, and supplemented by an optional information module on potential loads and benefits beyond the building life cycle. Table 3 shows the system boundary and scope of the EPD. The scope of this EPD is "cradle to gate with options" as defined by EN 15804. The intent of the EPD is to cover all significant impacts over the full life cycle. Due to the durability of PVC non pressure pipes, and lack of planned or required maintenance throughout the service life, modules B1-B7 were also deemed not relevant (of negligible impact).

TABLE 3 – SYSTEM BOUNDARY AND SCOPE OF THE STUDY

PRODUCT STAGE			CONSTRUCTION STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS & LOADS BEYOND THE SYSTEM BOUNDARY
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
RAW MATERIAL SUPPLY	TRANSPORT	MANUFACTURING	TRANSPORT	INSTALLATION	MATERIAL EMISSIONS	MAINTENANCE	REPAIR	REPLACEMENT	REFURBISHMENT	OPERATIONAL ENERGY	OPERATIONAL WATER	DECONSTRUCTION/DEMOLITION	TRANSPORT	WASTE PROCESSING	DISPOSAL	REUSE/RECYCLING/RECOVERY POTENTIAL
X	X	X	X	X	NR	NR	NR	NR	NR	NR	X	X	X	X	X	X

X = module included in EPD

NR = module not relevant (does not indicate zero impact result) – see text above table for explanation.

LIFE CYCLE OF IPLEX PVC PIPES

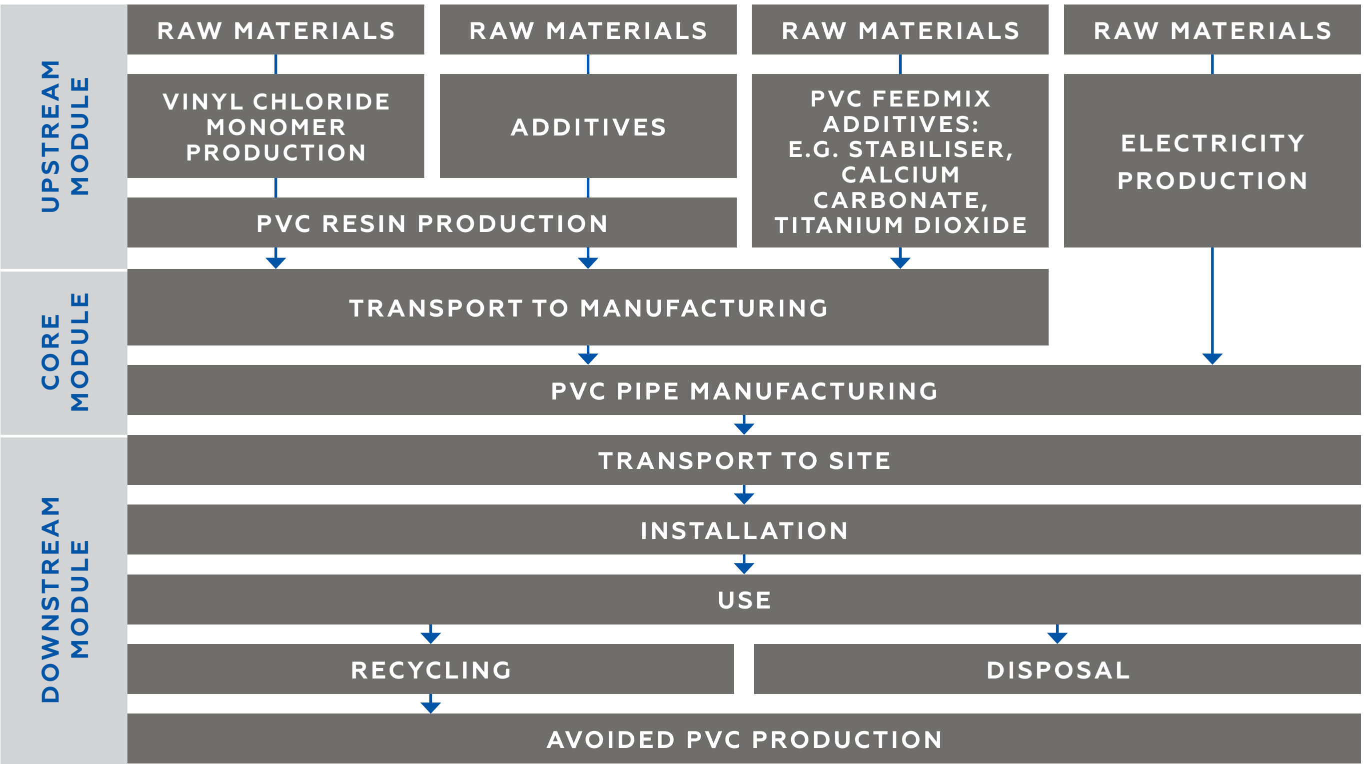


FIGURE 1 - LIFE CYCLE DIAGRAM OF PVC PIPE PRODUCTION

IPLEX PVC PIPE MANUFACTURING

Non-pressure PVC pipes are manufactured primarily from PVC resin along with additives, including: calcium carbonate, titanium dioxide, organic stabiliser, lubricants and pigments. In the case of foam core PVC pipe, azodicarbonamide is also used as a blowing agent. The PVC resin is the main ingredient in the PVC pipe feed mix, and is manufactured in Australia primarily from imported vinyl chloride monomer. The PVC resin and other additives are delivered to manufacturing site by bulk road tankers and are unloaded by a pneumatic system into storage silos. The mixing system incorporates resin and additives via computer controlled weighing systems. Internal PVC pipe scrap is fed back into the feed mix and utilised as the internal structure of foam core pipes also included in this EPD. The ingredients are then mixed by frictional means until enough heat is generated to incorporate the stabiliser and lubricant necessary for uniform processing at the extruder. Once mixed the blended feed mix is again stored in silos ready for extrusion – where the feed mix is gradually fed into the extruder via a gravimetric weighing system ensuring precise quantities. Through a combination of friction and heat, the feed mix is brought up to the ideal temperature for plastification, at which point it is forced through an annular die to form a tube. The newly formed pipe is then cooled by refrigerated water and the outside of the tube is subjected to a vacuum and brought in contact with a perfectly round sizing sleeve. The wall thickness is controlled with the computerised haul-off speed which also controls the saw which cuts the pipe at predetermined lengths. One end of the pipe is re-heated after cutting and expanded to allow for pipe joining. Finally the lengths of pipe are palletised, packaged with a softwood timber frame, steel and PET strapping. Iplex PVC manufacturing sites are shown above in Figure 2.

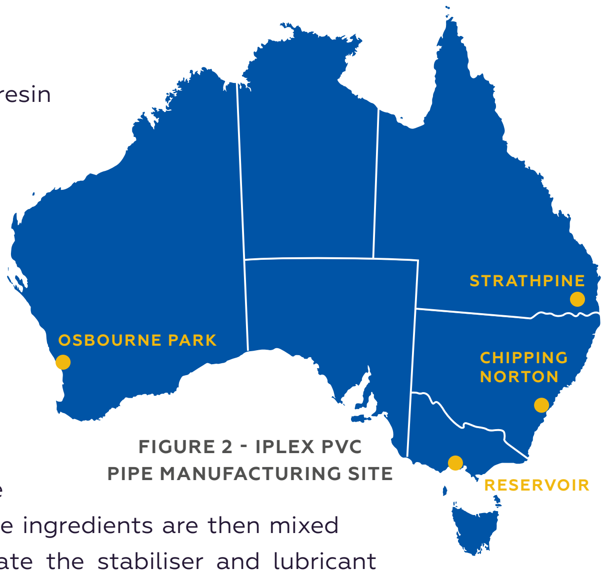


FIGURE 2 - IPLEX PVC PIPE MANUFACTURING SITE

DISTRIBUTION STAGE

Iplex has PVC pipe manufacturing facilities in Australia's major markets, and the vast majority of pipe distribution is over short distances within Sydney, Melbourne, Brisbane and Perth metropolitan areas. While some pipe will be transported a long distance, either into rural areas or interstate to Adelaide, Hobart and Darwin, the weighted average distance to site is estimated to be between 50 and 70km.

INSTALLATION STAGE

The majority of this type of pipe is installed inside buildings – in residential construction they are typically located in wall and floor cavities and for commercial and industrial applications often left exposed suspended from floor and ceiling surfaces as shown in the photograph. The pipes are carried by one person, cut by hand saw and positioned by hand – no machinery is used, it is all manual labour. The pipe systems are typically held in place by the penetration points at the walls or floor, or sometimes by brackets.

Jointing can be by rubber ring seals but the more common method in this group of pipe types would be to use solvent cement. The solvent softens the PVC and the close fit of the socket and spigot joint results in a chemical welding of the spigot to the socket. There is no heat required and minimal preparation based on having clean dry surfaces to apply solvent and then assemble the joint. Curing takes place quickly. Hold strength is reached in around 30 seconds and full cure achieved in less than 24 hours. No action or intervention of any kind is required to affect the curing process – simply waiting time before full service is recommended. There are tests performed at commissioning that confirm the installed system is leak free typically low pressure air and vacuum testing. These tests and the installation requirements are regulated and specified in the National Plumbing Code of Australia which is now part of the National Construction Code administered by the Australian Building Codes Board.

Wastage of pipe is minimal as short lengths are often required elsewhere and easily reused on subsequent sites or within the same site. A very rough estimate puts wastage from unusable offcuts at less than 2%.

USE STAGE

Maintenance of the pipe systems is not required and not planned. These systems are designed with this in mind as access to these systems in a finished building is often limited given their location in floor slabs or behind finished walls and ceilings. The pipe systems are designed to outlast the building with a life expectancy of in excess of 100 years. The failure rate is also extremely low and is considered to be inconsequential (not relevant) in this EPD. Post installation problems, if any, tend to be linked to third party damage such as inadvertently drilling through pipes behind ceiling and wall finishes. Apart from PVC pipes containing lead stabilisers*, there are no significant emissions from leaching of chemicals during the use stage for PVC pipes (European Commission, 2004). In the case that pipe is damaged, repair is simple using either a mechanical clamp or cutting out a small section (typically only 100mm in the case of a drilled hole or misdirected fastener type of incident) and replacing with a new section of pipe or simply a repair sleeve fitting – accessing the pipe to effect the work will generally be the most challenging aspect of a repair.

**Iplex PVC pipe contains no heavy metals.*

END OF LIFE

PVC plastics pipe systems are readily recyclable and are currently recycled in all capital cities in Australia. Practically all pre-consumer pipe waste is recycled at manufacturing locations and post-consumer pipe waste recycling is on the rise. Due to fact that plastic pipes are a relatively new product with a very long service life, most plastic pipe that has been installed in Australia is still in its first life time. Plastic pipe therefore represents a very small proportion of waste going to landfill – a fact confirmed by an audit of construction and demolition waste in NSW from 2011 (DSEWPC, 2011). PVC pipe can be recycled 6-7 times without significant reduction in pipe material quality requirements. Assuming a pipe life time of 100 years, the PVC material in PVC pipes may have a life time in excess of 600 years.

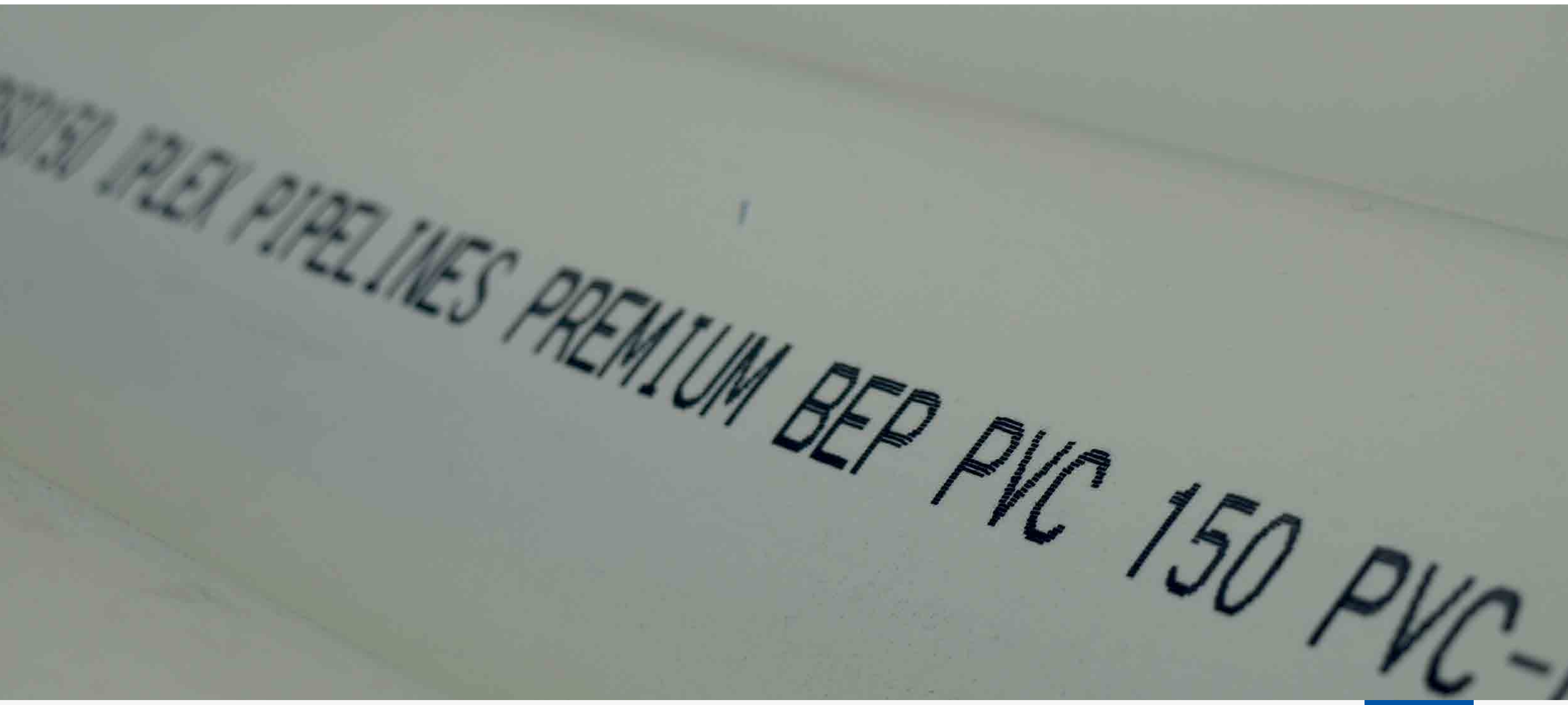
Due to a lack of national data on PVC pipe recycling, recycling rates were calculated by using best estimates for PVC pipe waste generation and recycling in NSW. Based on estimates by the former Department of Environment and Climate Change (DECC) and subsequent discussions with PIPA, it was estimated that there is approximately 1,300 tonnes of PVC pipe entering the waste stream each year in NSW. The current amount of PVC pipe recycled in NSW is approximately 350 tonnes, giving a recycling rate of 26.9%. This recycled PVC material is used in an innovative product range where the recycylate is used to manufacture new pipe with the same life and performance expectations as pipe made solely from virgin material. It is good to know that even when that long service life has been achieved that it can be recycled again back into pipe with exactly the same performance and life expectancy as the original pipe. So not only does plastic pipe connect Australia, it is also very much in the loop as far as recycling is concerned.

4.0 LIFE CYCLE ASSESSMENT METHODOLOGY

This section includes the main details of the LCA study as well as assumptions and methods of the assessment. A summary of the life cycle assessment parameters is given in Table 4.

TABLE 4 - DETAILS OF LCA

DECLARED UNIT	1kg of installed pipe
GEOGRAPHICAL COVERAGE	Australia
LCA SCOPE	Cradle to gate with options
REFERENCE SERVICE LIFE	100 years - While the design life of the PVC pipe is in excess of 100 years, the duration of the pipe use in buildings will be less for buildings with a shorter lifetime



Life cycle thinking is a core concept in sustainable consumption and production for policy and business. Upstream and downstream consequences of decisions must be taken into account to help avoid the shifting of burdens from one type of environmental impact to another, from one political region to another, or from one stage to another in a product's life cycle from the cradle to the grave.

LCA is the compilation of the inputs, outputs and environmental impacts of a product system throughout its life cycle. It is a technique that enables industries to identify the resource flows and environmental impacts (such as greenhouse gas emissions, water and energy use) associated with the provision of products and services.

According to EN 15804, EPDs of construction products may not be comparable if they do not comply with this standard, and EPDs might not be comparable, particularly if different functional units are used.

CORE DATA COLLECTION

Life cycle data has been sourced from material quantity data and production process data from:

- Iplex's reporting systems and staff
- Iplex feed mix suppliers, including the Australian Vinyl Corporation, Sun Ace and Omya Australia.

Core manufacturing data was collected directly from Iplex manufacturing sites. Electricity consumption was allocated to pipe via mass of pipe produced.

BACKGROUND DATA

Generic background data was sourced for raw materials in the upstream module, transportation and end of life waste treatment. Background data was adapted to represent Iplex PVC pipe product as accurately as possible. Australian inputs were primarily modelled with the AusLCI database (AusLCI, 2009) and the Australasian Unit Process LCI (Life Cycle Strategies, 2015) and the ecoinvent v3 database where suitable Australian data was not available. Materials sourced from outside Australia were modelled based on global averages using the ecoinvent v3 database. Global averages were used since the sourcing of these materials often changes from year to year. All background data used was less than 10 years old.

CUT OFF CRITERIA

Environmental impacts relating to personnel, infrastructure, and production equipment not directly consumed in the process are excluded from the system boundary as per the PCR (IEPDS, 2015), section 6.6. All other reported data were incorporated and modelled using the best available life cycle inventory data, except for the PVC ingredient Calcium Stearate - 61G, which was excluded due to lack of suitable background data. The excluded ingredient makes up less than 0.1% of the total feed mix mass.

ALLOCATION

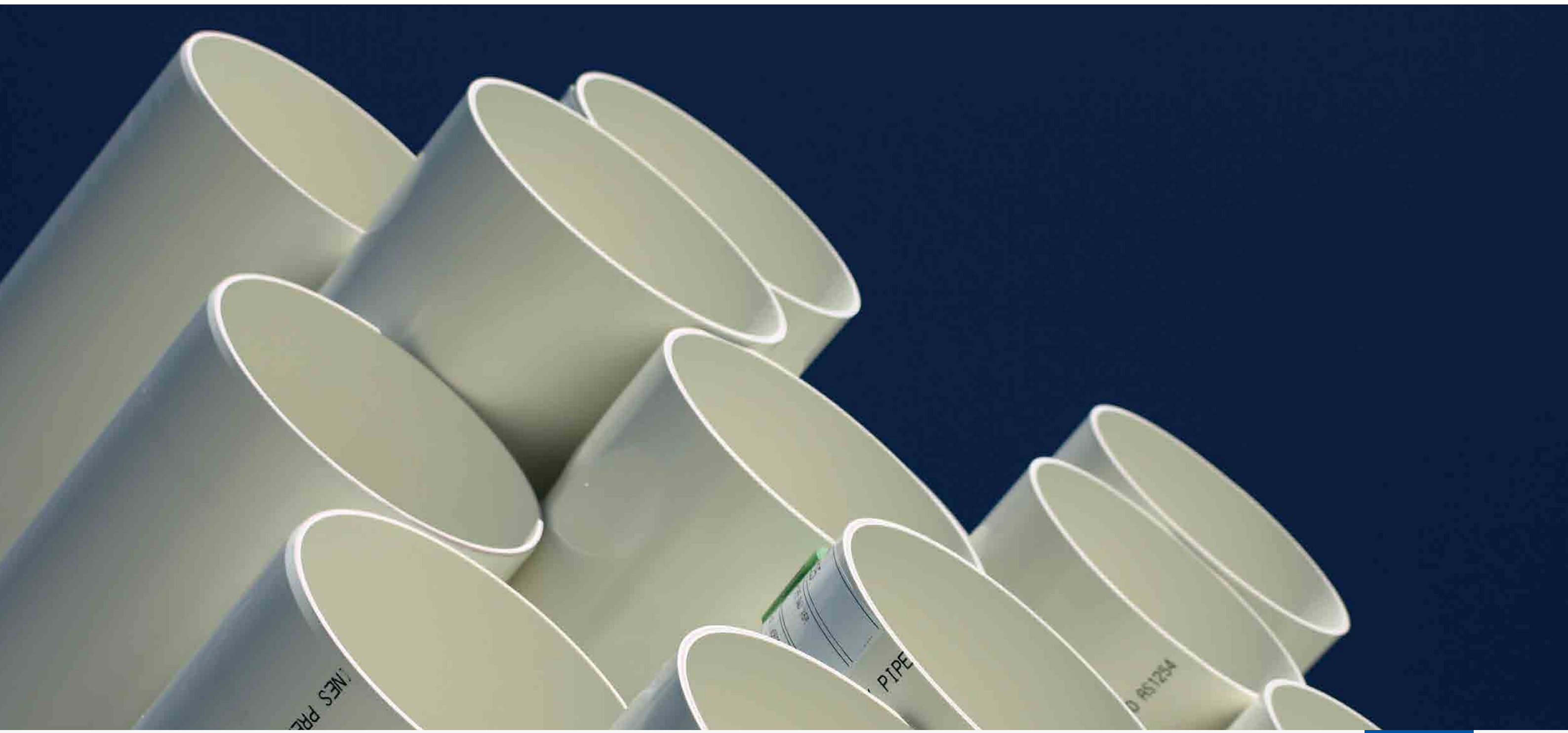
Allocation was carried out in accordance with the PCR (IEPDS, 2015), section 6.7. No-allocation between co-products in the core module as there were no co-products created during manufacturing.

VARIATION

The background LCA report tested the variation in results between manufacturing locations. The manufacturing location lead to significant variance between the production impacts at Iplex sites, however the purpose of this EPD is to represent the average Iplex PVC pipe product supplied to the Australian market. By including all four manufacturing sites all in different states, this EPD is representative of the average production and is less susceptible to variation when production volumes alter.

PVC-U NON-PRESSURE PIPE ENVIRONMENTAL PERFORMANCE

The potential environmental impacts used in this EPD are explained in Table 5 and the results for Iplex PVC-U non-pressure pipe are shown in Table 6. The use of energy and fresh water resources is shown in Table 7. The use of secondary material and secondary material used as energy resources is listed as ‘INA’ (indicator not assessed). Although Iplex do not directly use secondary material, it is unknown whether secondary material is used in the supply chain and therefore exists in the product life cycle. Table 8 shows the generation of waste throughout the product life cycle.



5.0 PVC PIPE ENVIRONMENTAL PERFORMANCE

TABLE 5 - ENVIRONMENTAL INDICATORS USED IN THE EPD

ENVIRONMENTAL INDICATOR		UNIT	DESCRIPTION
	GLOBAL WARMING POTENTIAL [A]	KG CARBON DIOXIDE EQUIVALENTS	Increase in the Earth's average temperature, mostly through the release of greenhouse gases. A common outcome of this is an increase in natural disasters and sea level rise.
	OZONE DEPLETION POTENTIAL [B]	KG CFC-11 EQUIVALENTS	The decline in ozone in the Earth's stratosphere. The depletion of the ozone layer increases the amount of UVB that reaches the Earth's surface. UVB is generally accepted to be a contributing factor to skin cancer, cataracts and decreased crop yields.
	ACIDIFICATION POTENTIAL [C]	KG SULPHUR DIOXIDE EQUIVALENTS	A process whereby pollutants are converted into acidic substances which degrade the natural environment. Common outcomes of this are acidified lakes and rivers, toxic metal leaching, forest damage and destruction of buildings.
	EUTROPHICATION POTENTIAL [C]	KG PHOSPHATE EQUIVALENTS	An increase in the levels of nutrients released to the environment. A common outcome of this is high biological productivity that can lead to oxygen depletion, as well as significant impacts on water quality, affecting all forms of aquatic and plant life.
	PHOTOCHEMICAL OZONE CREATION POTENTIAL [C]	KG ETHYLENE EQUIVALENTS	Ozone in the troposphere is a constituent of smog that is caused by a reaction between sunlight, nitrogen oxide and volatile organic compounds (VOCs). This is a known cause for respiratory health problems and damage to vegetation.
	ABIOTIC DEPLETION POTENTIAL – ELEMENTS / MINERALS [C]	KG ANTIMONY EQUIVALENTS	The extraction of non-living and non-renewable elements and minerals. These resources are essential in our everyday lives and many are currently being extracted at an unsustainable rate.
	ABIOTIC DEPLETION POTENTIAL – FOSSIL FUELS [C]	MJ NET CALORIFIC VALUE	The extraction of non-living and non-renewable fossil fuels. These resources are essential in our everyday lives and many are currently being extracted at an unsustainable rate.

Life cycle impact assessment methods used: a - CML (v4.1) – based on IPCC AR4 (GWP 100); **b** - CML (v4.1) – based on WMO 1999; **c** - CML (v4.1)

TABLE 6 - POTENTIAL ENVIRONMENTAL IMPACTS PER 1KG OF INSTALLED PVC NON-PRESSURE PIPE (AVERAGE SOLID AND FOAM CORE)

	A1 & 2	A3	A4	A5	C1	C2	C3	C4
GWP (kgCO_2 eq)	2.77	0.753	8.85E-03	6.03E-03	5.18E-05	0.0198	0.0578	0.0146
ODP (kgCFC11 eq)	5.22E-08	1.12E-09	2.87E-10	2.96E-11	1.28E-14	2.10E-09	2.95E-10	1.23E-09
AP (kgSO_2 eq)	8.11E-03	1.15E-03	2.19E-05	9.77E-06	3.28E-07	7.66E-05	9.15E-05	5.96E-05
EP (kgPO_4^{3-} eq)	1.93E-03	3.74E-04	5.47E-06	2.94E-06	6.82E-08	1.94E-05	2.87E-05	1.50E-05
POCP (kgC_2H_2 eq)	3.30E-04	4.31E-05	1.42E-06	4.28E-07	1.16E-08	4.92E-06	3.36E-06	3.67E-06
ADPE (kgSb eq)	3.80E-06	6.19E-07	2.00E-08	6.38E-09	1.19E-12	1.02E-07	5.73E-08	6.00E-08
ADPF (MJ)	16.0	8.19	0.140	0.079	7.85E-04	0.289	0.691	0.212

GWP = Global Warming Potential, **ODP =** Ozone Depletion Potential, **AP =** Acidification Potential, **EP =** Eutrophication Potential, **POCP =** Photochemical Oxidant Formation Potential, **ADPE =** Abiotic Resource Depletion Potential – Elements, **ADPF =** Abiotic Resource Depletion Potential – Fossil Fuel

TABLE 7 - USE OF RESOURCES PER 1KG OF INSTALLED PVC NON-PRESSURE PIPE (AVERAGE SOLID AND FOAM CORE)

	A1 & 2	A3	A4	A5	C1	C2	C3	C4
PERE (MJ)	1.73	0.235	7.58E-04	2.44E-03	4.51E-07	3.86E-03	0.0244	2.56E-0
PERM (MJ)	0	0	0	0	0	0	0	0
PERT (MJ)	1.73	0.235	7.58E-04	2.44E-03	4.51E-07	3.86E-03	0.0244	2.56E-03
PENRE (MJ)	62.6	8.24	0.140	0.0803	7.85E-04	0.304	0.695	0.221
PENRM (MJ)	0	0	0	0	0	0	0	0
PENRT (MJ)	62.6	8.2	0.1	0.1	0.0	0.3	0.7	0.2
SM (kg)	INA	INA	INA	INA	INA	INA	INA	INA
RSF (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
NRSF (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
FW (m^3)	0.640	0.0764	2.50E-03	3.60E-03	6.62E-07	0.010	0.035	0.006

PERE = Use of renewable primary energy excluding raw materials, **PERM =** Use of renewable primary energy resources used as raw materials, **PERT =** Total use of renewable primary energy resources, **PENRE =** Use of non-renewable primary energy excluding raw materials, **PENRM =** Use of non-renewable primary energy resources used as raw materials, **PENRT =** Total use of non-renewable primary energy resources, **SM =** Use of secondary material, **RSF =** Use of renewable secondary fuels, **NRSF =** Use of non-renewable secondary fuels, **FW =** Use of net fresh water, **INA =** Indicator not accessed due to a limitation of the LCA tools and databases used to calculate the required resource flows. INA does not imply zero impact

TABLE 8 - GENERATION OF WASTE PER 1KG OF INSTALLED PVC NON-PRESSURE PIPE (AVERAGE SOLID AND FOAM CORE)

	A1 & A2	A3	A4	A5	C1	C2	C3	C4
HWD (kg)	0.0102	1.13E-06	9.38E-08	1.42E-08	6.10E-12	3.93E-07	1.37E-07	2.31E-07
NHWD (kg)	0.132	0.0554	8.99E-04	5.65E-03	7.31E-08	2.17E-03	0.0747	0.696
RWD (kg)	2.52E-06	1.77E-08	2.28E-09	1.15E-09	1.31E-13	8.48E-09	3.47E-09	4.99E-09

HWD = Hazardous waste disposed, **NHWD =** Non-hazardous waste disposed, **RWD =** Radioactive waste disposed

INTERPRETATION OF LCA RESULTS

The majority of environmental impact lies within the raw material supplied to Iplex manufacturing sites – comparatively little impact is caused by the PVC pipe manufacturing at Iplex sites. From the feed mix ingredients, PVC resin is responsible for the majority of all environmental impacts and use of resources, although additives were still found to have a significant impact.

SENSITIVITY ANALYSIS

AVERAGE PRODUCTION OF PVC PIPE

The results shown in this EPD are representative of the average PVC pipe production, incorporating PVC pipe of both solid wall and foam core construction. The raw materials used in the feed mix of these two products is largely similar, although a blowing agent is also used in the feed mix of foam core pipe. A sensitivity analysis was performed to assess the difference in impact between the solid wall and foam core pipe products. The results varied by less than 10% in all environmental impact categories apart from ozone depletion potential and photochemical oxidation which varied more. For solid wall pipe, photochemical oxidation was 26% higher, while foam core pipes ozone depletion potential was 37% higher.

END OF LIFE RECYCLING RATE

The assumption for end of life recycling rate was tested using low and high rates based on estimation ranges for PVC pipe in construction and demolition waste stream and current PVC pipe recycling rates. The amount of PVC pipe entering the waste stream is difficult to calculate due to low volumes and only recent targeted separation and collection. Estimates were made from PIPA PVC pipe recycling data and PVC waste data estimated by PIPA in collaboration with the former Department of Environment and Climate Change. A case study into PVC pipe recycling was published by the Department of Sustainability, Environment, Water, Pollution and Communities (DSEWPC, 2012). Using extremes of both PVC pipe waste and recycling rates gave a low recycling rate of 15.4% and a high of 61.5%. Both of these rates were tested and found to lead to a 6.8% increase and 14.8% decrease in global warming potential respectively – however this is only when including the potential benefits of recycling (Module D). When looking at only modules A1-C4, the environmental indicators did not vary considerably.

6.0 ADDITIONAL ENVIRONMENTAL INFORMATION

BEST ENVIRONMENTAL PRACTICE PVC

In 2010 the GBCA reviewed its Green Star rating tool and under a new approach, the use of Iplex PVC pressure and non-pressure pipe, conduit and fittings can assist buildings to qualify for up to two positive credit points where pipe and fittings can be shown to comply with the GBCA "Best Practice Guidelines for PVC in the Built Environment".

As a means of demonstrating Best Environmental Practice PVC (BEP PVC), Iplex was subjected to an extensive audit process by independent third party certifier, Approval Mark. On Monday 20th February 2012, Iplex was issued with BEP PVC Certificate of Compliance No. 037.

HEALTH RISK ASSESSMENT

The GBCA's Literature Review and Best Practice Guidelines for the Life Cycle of PVC Building Products (GBCA, 2010) provides an overview of health and environmental concerns that have been voiced by stakeholders relating to PVC production and end of life product management. Regarding concerns about additives, Iplex PVC pipe material is itself unplasticised PVC, and hence does not contain plasticiers – phthalates. Australian Standards for PVC pipe, as the only national PVC pipe product standards to do so worldwide, specifically exclude heavy metal (e.g. lead and cadmium) additives (PIPA, 2014). Furthermore, the Adaptation of the USGBC TSAC Report for Relevance to Australian DWV Pipe (BRANZ, 2008) found that for typical pipe products "No single material shows up as the best across all the human health and environmental impact categories, nor the worst". The GBCA further found that the level of dioxins emitted due to best practice production of PVC and its constituents is much less than that from other sources. Therefore, there is insufficient rationale for discrimination against PVC building products on the basis of dioxin emissions (GBCA, 2010).

GUIDANCE FOR PVC PIPE RECYCLING

PVC has a high recyclability and can be mechanically recycled back into a pipe product performing the same structural function as one made only from virgin material. Due to the long life of rigid PVC products and low volume in waste streams, there is also no current limitation for the amount of recycled PVC that can be utilised. The following key properties of Iplex PVC pipe aid recyclability:

- Iplex PVC pipe contains no plasticiser – so no phthalates
- There are no dioxins in Iplex PVC pipe
- Iplex PVC pipe contains no heavy metal additives – so no lead and no cadmium

Specific PVC recycling locations are available in Sydney, Melbourne and Brisbane and PVC-U pipe can be recycled at general plastic recycling stations throughout Australia.

MODULE D – RECYCLABILITY POTENTIALS

Recycled PVC materials are generally produced from mixed colour PVC, resulting in a brownish colour which is not suitable for all applications. This is due to PVC pipes being colour-coded for particular applications: water pipes are blue, electrical conduits are orange and stormwater pipes are white. There are also some limitations to re-purposing of recycled PVC e.g. EN-ISO 1452 does not permit any recycled PVC be used for water pipes.

The brownish colour of recycled material makes it most appropriate for multi-layer pipes (e.g. foam core or triple layer pipes), where the inside and outside are made from a virgin material and the middle layer (approximately half the pipe mass) can be made from up to 100% recyclate. Multi-layer pipes are more rigid and are normally used for non-pressure applications, such as electrical conduit pipe (DSEWPC, 2011).

Due to the long life of rigid PVC products and low volume in waste streams, there is also no current limitation for the amount of recycled PVC that can be utilised. According to a 2011 European study, up to 50% recycled PVC can be used in foam core pipes and a level of only 25% would consume more recycled rigid PVC than is currently available on the market (Fumire & Tan, 2012). PVC can be recycled up to six or seven times with almost no inherent quality degradation. Assuming a pipe product life of 100 years means that PVC material could potentially have a lifespan in excess of 600 years (DSEWPC, Waste and Recycling in Australia 2011, 2012). Small amount of contaminants can be adjusted for by varying additives in the feed mix such as lubricants and processing aids.

The following tables represent the potential benefit from end of life recycling through offsetting the production of virgin PVC.

TABLE 9 - POTENTIAL ENVIRONMENTAL IMPACT RECYCLING, NET FLOW 0.147KG/KG (AVERAGE SOLID AND FOAM CORE)

	D – RECYCLABILITY POTENTIALS	IMPACT REDUCTION (%)
($kgCO_2$ eq)	-0.500	-14%
ODP (kgCFC11 eq)	-5.65E-10	-1%
AP ($kgSO_2$ eq)	-1.13E-03	-12%
EP (kgPO43- eq)	-3.07E-04	-13%
POCP (kgC_2H_2 eq)	-2.48E-05	-6%
ADPE (kgSb eq)	-5.62E-07	-12%
ADPF (MJ)	-1.54	-6%

GWP = Global Warming Potential, **ODP =** Ozone Depletion Potential, **AP =** Acidification Potential, **EP =** Eutrophication Potential, **POCP =** Photochemical Oxidant Formation Potential, **ADPE=** Abiotic Resource Depletion Potential – Elements, **ADPF =** Abiotic Resource Depletion Potential – Fossil Fuel

TABLE 10 - POTENTIAL BENEFITS IN RESOURCE USE FROM RECYCLING, NET FLOW 0.147KG/KG (AVERAGE SOLID AND FOAM CORE)

	D – RECYCLABILITY POTENTIALS	RESOURCE USE REDUCTION (%)
PERE (MJ)	-0.374	-19%
PERM (MJ)	0	0
PERT (MJ)	-0.374	-19%
PENRE (MJ)	-12.0	-17%
PENRM (MJ)	0	0
PENRT (MJ)	-12.0	-17%
SM (kg)	INA	INA
RSF (MJ)	INA	INA
NRSF (MJ)	INA	INA
FW (m^3)	-0.068	-9%

PERE = Use of renewable primary energy excluding raw materials, **PERM =** Use of renewable primary energy resources used as raw materials, **PERT =** Total use of renewable primary energy resources, **PENRE =** Use of non-renewable primary energy excluding raw materials, **PENRM =** Use of non-renewable primary energy resources used as raw materials, **PENRT =** Total use of non-renewable primary energy resources, **SM =** Use of secondary material, **RSF =** Use of renewable secondary fuels, **NRSF =** Use of non-renewable secondary fuels, **FW =** Use of net fresh water, **INA =** Indicator not assessed

TABLE 11 - POTENTIAL REDUCTION IN WASTE GENERATION BY RECYCLING, NET FLOW 0.147KG/KG (AVERAGE SOLID AND FOAM CORE)

	D – RECYCLABILITY POTENTIALS	RESOURCE USE REDUCTION (%)
HWD (kg)	-2.31E-03	-23%
NHWD (kg)	-0.0136	-1%
RWD (kg)	-3.75E-09	-0.1%

HWD = Hazardous waste disposed, **NHWD =** Non-hazardous waste disposed, **RWD =** Radioactive waste disposed

7.0 PRODUCT SPECIFICATIONS

The following tables (Table 12 and Table 13) can be used to calculate the environmental results for specific Iplex pipe products. The unit weight and length of pipe give the total mass of pipe for each product code.

TABLE 12 - PRODUCT SPECIFICATIONS FOR PVC SOLID WALL PIPE PRODUCTS

APPLICATION	PRODUCT CODE	DN NOMINAL SIZE (MM)	STIFFNESS / PRESSURE RATING	LENGTH (M)	MINIMUM MEAN OUTSIDE DIAMETER (MM)	MASS (KG/M)
Stormwater	WPSO75	75	N/A	6	75.0	0.583
Stormwater	WPSO90	90	N/A	6	90.0	0.813
Stormwater	WPSO90SL	90	N/A	6	90.0	0.813
Stormwater	WPSO90EH	90	N/A	6	90.0	1.09
Stormwater	WPSO150	150	N/A	6	160	2.43
Stormwater	WPSO225	225	N/A	6	250	5.91
Stormwater	WPSO300	300	N/A	6	315	9.54
Stormwater	WPSO375	375	N/A	6	400	15.36
DWV	DPSH40	40	SH	6	42.8	0.427
DWV	DPSH50	50	SH	6	55.7	0.612
DWV	DPSH65	65	SH	6	68.7	0.922
DWV	DPSH80	80	SH	6	82.3	1.19
Conduit	P900204	20	MD	4	19.7	0.165
Conduit	P900254	25	MD	4	24.7	0.213
Conduit	P900324	32	MD	4	31.7	0.318
Conduit	P900504	50	MD	4	49.7	0.660
Conduit	P600506WHT	50	HD	6	49.7	0.827
Conduit	CTL020	20	N/A	4.5	26.6	0.222
Conduit	CNBN20445	20	N/A	4.5	26.6	0.222
Conduit	CTC020	20	N/A	4.5	26.6	0.222
Conduit	CTLR50	50	N/A	4.5	60.2	0.749
Conduit	CNBN50445	50	N/A	4.5	60.2	0.749
Conduit	CTCR50	50	N/A	4.5	60.2	0.749

TABLE 13 - PRODUCT SPECIFICATIONS OF PVC FOAM CORE PIPE PRODUCTS

APPLICATION	PRODUCT CODE	DN NOMINAL SIZE (MM)	STIFFNESS / PRESSURE RATING	LENGTH (M)	MINIMUM MEAN OUTSIDE DIAMETER (MM)	MASS (KG/M)
DWV	DSMH100	100	SN6	6.0	110	1.23
DWV	DSME100	100	SN10	6.0	110	1.53
DWV	DSME100C	100	SN10	3.0	110	1.53
DWV	DSMH150	150	SN4	6.0	160	3.06
DWV	DRMH150C	150	SN4	3.0	160	3.06
DWV	DSME150	150	SN8	6.0	160	3.76
DWV	DSME150C	150	SN8	3.0	160	3.76
DWV	DSMH225	225	SN4	6.0	250	7.33
DWV	DRMH225C	225	SN4	3.0	250	7.33
DWV	DSME225	225	SN8	6.0	250	9.54
DWV	DSME225C	225	SN8	3.0	250	9.54
DWV	DSMH300	300	SN4	6.0	315	11.7
DWV	DRSH300C	300	SN4	3.0	315	11.7
DWV	DSEH300	300	SN8	6.0	315	14.9
DWV	DSEH300C	300	SN8	3.0	315	14.9
Conduit	P900806	80	N/A	6.0	88.7	1.54
Conduit	P600804WHT	80	N/A	4.0	88.7	1.41
Conduit	P900100445	100	N/A	4.5	114	1.97
Conduit	P9001006	100	N/A	6.0	114	1.97
Conduit	P6001004WHT	100	N/A	4.0	114	2.30
Conduit	P6001504WHT	150	N/A	4.0	160	4.38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